



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: <b>PCT/NL91/00050</b></p> <p>(22) International Filing Date: 26 March 1991 (26.03.91)</p> <p>(60) Parent Applications or Grants (63) Related by Continuation</p> <table> <tr> <td>US Filed on</td> <td>293,456 (CIP) 4 January 1989 (04.01.89)</td> </tr> <tr> <td>US Filed on</td> <td>446,877 (CIP) 6 December 1989 (06.12.89)</td> </tr> <tr> <td>US Filed on</td> <td>PCT/NL90/00182 (CIP) 13 December 1990 (13.12.90)</td> </tr> </table> <p>(71) Applicant (for all designated States except US): <b>SPECTRUM SCIENCES B.V. [NL/NL]; Zijdeweg 6, NL-2244 BG Wassenaar (NL)</b></p>		US Filed on	293,456 (CIP) 4 January 1989 (04.01.89)	US Filed on	446,877 (CIP) 6 December 1989 (06.12.89)	US Filed on	PCT/NL90/00182 (CIP) 13 December 1990 (13.12.90)	<p>(72) Inventor; and (75) Inventor/Applicant (for US only): <b>LANDA, Benzion [CA/CA]; 10010-119 Street, Edmonton, Alberta T5K 1Y8 (CA)</b></p> <p>(74) Agent: <b>DE BRUIJN, Leendert, C.; Nederlandsch Octrooibureau, Scheveningseweg 82, P.O. Box 29720, NL-2502 LS The Hague (NL)</b></p> <p>(81) Designated States: <b>AT (European patent), BE (European patent), CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, KR, LU (European patent), NL (European patent), SE (European patent), US</b></p> <p><b>Published</b> <i>With international search report.</i></p>	
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<p>(54) Title: <b>IMAGING SYSTEM WITH INTERMEDIATE TRANSFER MEMBERS</b></p> <p>(57) Abstract</p> <p>Imaging apparatus for printing an image on a substrate (42) from a latent image formed on a latent image bearing surface (16) including developing apparatus (22) for developing the latent image/with toner to form a developed toner image of a given size, a first intermediate transfer member (40) having a surface area large enough to accommodate the developed toner image, first transfer means for transferring the developed toner image from the latent image bearing surface (16) to the first intermediate transfer member (40), a second intermediate transfer member (47) having a surface area smaller than the surface area of the first intermediate transfer member (40), and second transfer means for transferring of said developed image from said first intermediate transfer member (40) to said second intermediate transfer member (47) and from said second intermediate transfer member (47) to said substrate (42). Preferably the second intermediate transfer means (47) is a cylinder having a diameter of less than 30 or 40 mm.</p>									

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1           **IMAGING SYSTEM WITH INTERMEDIATE TRANSFER MEMBERS**

2           **FIELD OF THE INVENTION**

3           The present invention relates to image transfer  
4 techniques and apparatus for use in electrophotography.

5           **BACKGROUND OF THE INVENTION**

6           Various prior publications deal with the transfer of  
7 single and multiple powder and liquid toner images from a  
8 photoreceptor on which they are formed to an intermediate  
9 transfer member for subsequent transfer to a final substrate.

10          U. S. Patent 3,838,919 to Takahashi describes a powder  
11 toner system in which color toner images are sequentially  
12 formed on an image forming member, individually transferred  
13 to an intermediate transfer member and transferred at one  
14 time to a recording member.

15          U. S. Patent 4,144,808 to Isawa et al. describes a  
16 method of printing on a metal plate utilizing powder toner  
17 and an intermediate transfer member where the plate is  
18 heated before transfer.

19          U. S. Patent 4,518,976 to Tarumi et al. describes a  
20 monochrome powder toner system in which a powder image is  
21 developed on a photoreceptor, and transferred  
22 electrostatically to an intermediate transfer member.  
23 Downstream this transfer, the intermediate transfer member  
24 and the image thereon are heated before transfer to a  
25 preheated substrate.

26          U. S. Patent 4,515,460 to Knechtel, describes a powder  
27 toner apparatus wherein separate toner images are  
28 sequentially developed on a photoreceptor and  
29 electrostatically transferred to an intermediate transfer  
30 member. After all of the individual images have been  
31 transferred to the intermediate transfer member, they are  
32 transferred electrostatically to the final substrate. No  
33 heating of the images or substrate is disclosed.

34          U. S. Patent 4,585,319 to Okamoto et al. describes a  
35 powder developer type, single color system, utilizing a  
36 temperature controlled photoreceptor, a heated intermediate  
37 transfer member and a heated transfer fixing roller which is  
38 heated to a temperature slightly higher than that of the

1 intermediate transfer member.

2 U. S. Patent 4,690,539 to Radulski et al. describes a  
3 liquid toner multi-color system in which a color image is  
4 developed on a photoreceptor and transferred to a belt type  
5 intermediate transfer member. The liquid carrier is removed  
6 from the toner image on the belt. There is no mention of  
7 heating the intermediate transfer member or of the problem of  
8 back transfer.

9 U. S. Patent 4,708,460 to Langdon describes a single  
10 color liquid toner system in which a developed image is  
11 transferred from a photoreceptor to an intermediate transfer  
12 member, heated on the transfer member and then transferred to  
13 a final substrate.

14 U. S. Patent 3,847,478 to Young describes a duplex  
15 printing system, wherein a developed image is transferred  
16 from a photoconductor to an intermediate transfer member, a  
17 second image is developed on the photoconductor and both  
18 images are transferred electrostatically to opposite sides of  
19 a piece of paper passed between the intermediate transfer  
20 member and the photoreceptor.

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## **SUMMARY OF THE INVENTION**

2 The present invention seeks to provide improved  
3 apparatus for the transfer of an image from an image bearing  
4 surface to an intermediate transfer member and subsequent  
5 transfer to a final substrate.

6 There is thus provided in accordance with a preferred  
7 embodiment of the invention imaging apparatus for printing an  
8 image on a substrate from a latent image formed on a latent  
9 image bearing surface including developing apparatus for  
10 developing the latent image with toner, preferably with  
11 liquid toner having carrier liquid and toner particles, to  
12 form a developed toner image of a given size, a first  
13 intermediate transfer member, preferably having a cylindrical  
14 shape and having a surface area large enough to accommodate  
15 the developed toner image, first transfer apparatus for  
16 transferring the developed toner image from the latent image  
17 bearing surface to the first intermediate transfer member, a  
18 second intermediate transfer member, preferably a cylindrical  
19 shape having a surface area smaller than the surface area of  
20 the first intermediate transfer member and second transfer  
21 apparatus for transferring of the developed image from the  
22 first intermediate transfer member to the second intermediate  
23 transfer member and from the second intermediate transfer  
24 member to the substrate.

25 Preferably the second intermediate transfer member is not  
26 large enough to accomodate the developed image.

27 In a preferred embodiment of the invention the imaging  
28 apparatus includes heating apparatus for heating the first  
29 intermediate transfer member to a first temperature and for  
30 heating the second intermediate transfer member to a second  
31 temperature higher than the first temperature.

32 Preferably the second transfer apparatus includes  
33 apparatus for heating the substrate, preferably including a  
34 heating backing roller operative to apply heat and pressure  
35 to the image during image transfer to the substrate.

36 In a preferred embodiment of the invention the imaging  
37 apparatus also includes first voltage apparatus for  
38 maintaining the first intermediate transfer member at a first

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1 voltage. Preferably at least a portion of the latent image  
2 bearing surface is at a second voltage and the first voltage  
3 is different from the second voltage. Preferably the imaging  
4 apparatus also includes second voltage means for maintaining  
5 the second intermediate transfer member at a third voltage.

6 Preferably the second intermediate transfer member has a  
7 diameter of less than about 40 mm, more preferably a diameter  
8 of less than about 30 mm.

9 In a preferred embodiment of the invention transfer of  
10 the developed image from the second intermediate transfer  
11 member to the substrate commences before transfer of the  
12 developed image from the first intermediate transfer member  
13 to the second transfer member is complete.

14 In a preferred embodiment of the invention the imaging  
15 apparatus includes means for producing a plurality of  
16 developed images on the image bearing surface and for  
17 transferring the plurality of developed images to the first  
18 transfer member in mutual alignment thereon.

19 BRIEF DESCRIPTION OF THE DRAWINGS

20 The present invention will be understood and appreciated  
21 more fully from the following detailed description, taken in  
22 conjunction with the drawings in which:

23 Fig. 1 is a simplified sectional illustration of  
24 electrophotographic apparatus constructed and operative in  
25 accordance with a preferred embodiment of the present  
26 invention;

27 Fig. 2 is a simplified sectional illustration of  
28 electrophotographic apparatus constructed and operative in  
29 accordance with another preferred embodiment of the present  
30 invention;

31 Fig. 3A is a simplified sectional illustration of elec-  
32 trophotographic apparatus constructed and operative in ac-  
33 cordance with yet another preferred embodiment of the present  
34 invention;

35 Fig. 3B is a simplified sectional illustration of elec-  
36 trophotographic apparatus constructed and operative in ac-  
37 cordance with yet another preferred embodiment of the present  
38 invention;

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1 Fig. 4 is a simplified sectional illustration of a elec-  
2 trophotographic apparatus constructed and operative in ac-  
3 cordance with yet another preferred embodiment of the present  
4 invention;

5 Fig. 5 is a simplified sectional illustration of  
6 electrophotographic apparatus constructed and operative in  
7 accordance with yet another preferred embodiment of the  
8 present invention;

9 Fig. 6 is a simplified sectional illustration of  
10 electrophotographic apparatus constructed and operative in  
11 accordance with yet another preferred embodiment of the  
12 present invention; and

13 Fig. 7 is a graphical illustration of the temperature  
14 variation along a low thermal mass intermediate transfer  
15 member in an arrangement such as that illustrated in Fig. 6.

16 DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

17 Reference is now made to Fig. 1 which illustrates  
18 electrophotographic imaging apparatus constructed and  
19 operative in accordance with a preferred embodiment of the  
20 present invention. This and other embodiments of the  
21 invention are described in the context of liquid developer  
22 systems with negatively charged toner particles and  
23 positively charged photoreceptors. Such systems operate in a  
24 "write-white" mode, for which areas which are not to be toned  
25 are exposed to light. The invention may be useful for other  
26 combinations of toner charge, photoreceptor charge as well as  
27 for other writing systems, such as "write-black" systems.

28 The apparatus of the invention is described using a  
29 liquid developer system. In accordance with a preferred  
30 embodiment of the invention the liquid developer of Example 1  
31 of U. S. Patent 4,794,651 can be used, but other suitable  
32 developers may be used in the practice of the invention.  
33 Especially useful are liquid developers comprising toner  
34 particles which solvate the carrier liquid of the developer  
35 at elevated temperatures, above room temperature.

36 As in conventional electrophotographic systems, the  
37 apparatus of Fig. 1 comprises a drum 10 arranged for rotation  
38 about an axle 12 in a direction generally indicated by arrow

1 14. Drum 10 is formed with a cylindrical photoreceptor  
2 surface 16.

3 A corona discharge device 18 is operative to generally  
4 uniformly charge photoreceptor surface 16 with a positive  
5 charge. Continued rotation of drum 10 brings charged  
6 photoreceptor surface 16 into image receiving relationship  
7 with an exposure unit including a lens 20. Lens 20, focuses a  
8 desired image, which may be laser generated, onto charged  
9 photoreceptor surface 16, selectively discharging the  
10 photoreceptor surface, thus producing an electrostatic  
11 latent image thereon.

12 Continued rotation of drum 10 brings charged  
13 photoreceptor surface 16 bearing the electrostatic latent  
14 image into operative association with a development unit 22,  
15 operative to apply a liquid developer to develop the  
16 electrostatic latent image. For multicolor copying or  
17 printing, the development unit 22 can, for example, comprise  
18 a plurality of developers, one for each color, which are  
19 selectively engaged with the photoreceptor, as described, for  
20 example, in U.S. Patent 4,690,539, which is incorporated  
21 herein by reference, or a single development station where  
22 the liquid toner is changed between colors, or any other  
23 suitable development system. In general this development  
24 process takes place at a relatively low temperature, namely  
25 approximately the temperature of the environment of the  
26 system.

27 In accordance with a preferred embodiment of the  
28 invention, following application of toner thereto,  
29 photoreceptor surface 16 passes a typically positively  
30 charged rotating roller 26, preferably rotating in a  
31 direction indicated by an arrow 28. Roller 26 functions as a  
32 metering roller and reduces the thickness of liquid on  
33 photoreceptor surface 16. Typically the spatial separation of  
34 roller 26 from photoreceptor surface 16 is about 50 microns.

35 Preferably the voltage on roller 26 is intermediate the  
36 voltages of the latent image areas and of the background  
37 areas on the photoreceptor surface. Typical voltages are:  
38 roller 26: +200V, background area: +50V and latent image

1 areas: up to about +1000V.

2       Liquid which passes roller 26 should be relatively free  
3 of pigmented particles except in the region of the latent  
4 image.

5       Downstream of roller 26 there is preferably provided a  
6 rigidizing roller 30. Rigidizing roller 30 is preferably  
7 formed of a resilient polymeric material, for example a  
8 slightly conductive resilient polymeric material as described  
9 in either or both of U.S. Patents 3,959,574 and 3,863,603  
10 the disclosures of which are incorporated herein by  
11 reference. Roller 30 is preferably resiliently urged against  
12 photoconductive surface 16.

13       In a preferred embodiment of the invention, an electri-  
14 cally biased squeegee roller is used as roller 30. Roller 30  
15 is negatively charged to a potential of at least several  
16 hundred and up to 2000 volts with the same sign as the charge  
17 on the pigmented toner particles, so that it repels similarly  
18 charged pigmented particles and causes them to more closely  
19 approach the image areas of the photoreceptor surface 16,  
20 thus compressing and rigidizing the image.

21       Downstream of rigidizing roller 30 there is provided an  
22 intermediate transfer member 40, which rotates in a direction  
23 opposite to that of photoreceptor surface 16, as shown by  
24 arrow 41, providing zero relative motion between their  
25 respective surfaces at the point of propinquity. Intermediate  
26 transfer member 40 is operative for receiving the toner image  
27 from photoreceptor surface 16 and for transferring the toner  
28 image to a receiving substrate 42, such as paper. Disposed  
29 internally of intermediate transfer member 40 there may be  
30 provided a heater 46, to heat intermediate transfer member  
31 40.

32       Various types of intermediate transfer members are known  
33 and are described, for example in U.S. Patent 4,684,238, PCT  
34 Publication WO 90/04216 and U. S. Patent 4,974,027 the  
35 disclosures of all of which are incorporated herein by  
36 reference.

37       Following the transfer of the toner image to  
38 intermediate transfer member 40, photoreceptor surface 16

1 engages a cleaning station 49. This station may be any  
2 conventional cleaning station, comprising a cleaning roller  
3 50 which may comprise a suitable resilient material such as  
4 foam polyethylene or neoprene. Cleaning roller 50 may be  
5 wetted by clean lubricating cleaning liquid, which preferably  
6 comprises liquid developer from which all or nearly all of  
7 the toner particles have been removed. Cleaning roller 50 is  
8 driven so that its surface moves opposite to surface 16 at  
9 their nip, to provide scrubbing action for removal of  
10 residual particles and carrier liquid from photoreceptor  
11 surface 16. A scraper 56 completes the removal of any  
12 residual toner which may not have been removed by cleaning  
13 station 49.

14 A lamp 58 completes the cycle by removing any residual  
15 charge, characteristic of the previous image, from  
16 semiconductor surface 16.

17 Transfer of the image to intermediate transfer member 40  
18 is preferably aided by providing electrification of  
19 intermediate transfer member 40 to a voltage opposite that of  
20 the charged particles, thereby causing transfer by  
21 electrophoresis. It has been found by the inventors, that, at  
22 least for the preferred developer, raising the temperature of  
23 the developed toner image to a temperature higher than the  
24 development temperature and room temperature aids this first  
25 transfer, even when the transfer is by electrophoresis.

26 Subsequent final transfer of the image from intermediate  
27 transfer member 40 to substrate 42 is preferably aided by  
28 heat and pressure. A higher temperature than that used for  
29 first transfer is preferably utilized for this subsequent  
30 final transfer, in accordance with the present invention.

31 In the prior art a liquid toner image was first  
32 transferred to an intermediate transfer member. The toner  
33 image was heated during the interval between first and second  
34 transfer so as to aid in final transfer.

35 In the present invention the preferred first transfer  
36 step, i.e., the transfer of the liquid toner image to the  
37 intermediate transfer member includes the heating of the  
38 image either before or during first transfer. The preferred

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1 final transfer step, i.e., the transfer of the liquid toner  
2 image to the final substrate, includes the further heating of  
3 the image before and/or during second transfer. This further  
4 heating can be achieved by heating the image on intermediate  
5 transfer member 40, for example by heat transfer from  
6 intermediate transfer member 40 during the interval between  
7 first and final transfer and/or by external heating of the  
8 image. Preferably the image is heated to a temperature at  
9 which it solvates liquid to form a single phase, without  
10 evaporating substantial amounts of liquid carrier.  
11 Alternatively or additionally the further heating can be  
12 achieved by conduction heating of the image from the final  
13 substrate during final transfer.

14 These preferred first and second transfer steps improve  
15 the quality of the image on the final substrate both for  
16 single color and for multi-color images.

17 For multicolor systems it is useful to sequentially  
18 transfer the separate colors to intermediate transfer member  
19 40 in alignment with and generally superimposed and in  
20 registration with each other and then to transfer them  
21 together to paper or other substrate 42. It has then been  
22 found that for this configuration, there is a tendency for  
23 the heated images previously transferred to the intermediate  
24 transfer member at a lower temperature, to transfer back, in  
25 whole or in part, to photoreceptor surface 16, when the  
26 previously transferred image returns to the point of first  
27 transfer.

28 The embodiments of the invention described herein  
29 provide improved first and final transfer and for multicolor  
30 systems can solve the back transfer problem.

31 In general, some of the embodiments of the invention are  
32 characterized in that photoreceptor 16 is at a first,  
33 relatively low temperature; intermediate transfer member 40  
34 is at a second, somewhat higher temperature, to provide for  
35 improved first transfer; and final substrate 42 is at a  
36 third, even higher temperature to provide for good transfer  
37 from intermediate transfer member 40 to substrate 42.

38 Alternatively or additionally, some of the embodiments

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1 can be characterized in that, when a toner image is  
2 transferred from photoreceptor surface 16 to intermediate  
3 transfer member 40, and then to final substrate 42, the toner  
4 image is hotter during transfer to the intermediate transfer  
5 member than it was on the photoreceptor surface and the image  
6 is hotter when it is transferred to the final substrate, than  
7 during the earlier transfer.

8 Alternatively or additionally, some of the embodiments  
9 can be characterized in that, when multiple toner images are  
10 transferred sequentially from photoreceptor surface 16 to  
11 intermediate transfer member 40, and then to final substrate  
12 42 as a group, the composite, multicolor toner image is  
13 hotter when it is transferred to the final substrate than  
14 during any contact of earlier transferred images with the  
15 photoreceptor.

16 One embodiment of the invention can be characterized in  
17 that the image is transferred from a photoreceptor surface,  
18 at a first relatively low temperature to a first intermediate  
19 transfer member at a second intermediate temperature. The  
20 image is then transferred to a second intermediate transfer  
21 member. Final transfer takes place from the second  
22 intermediate transfer member to the final substrate at a  
23 third, higher temperature. Preferably, the image temperature  
24 during first transfer is higher than that of that portion of  
25 the photoreceptor surface not in contact with the  
26 intermediate transfer member.

27 Returning now to Fig. 1, intermediate transfer member 40  
28 is heated to a temperature sufficient to enhance the  
29 electrophoretic transfer of toner particles from  
30 photoreceptor surface 16 to intermediate transfer member 40.  
31 The image is heated during transfer to intermediate transfer  
32 member 40, and the heating continues while the image is on  
33 intermediate transfer member 40 until the image is at the  
34 temperature of intermediate transfer member 40. Rotation of  
35 intermediate transfer member 40 brings the heated  
36 intermediate transfer member 40 into image transfer  
37 relationship with a final substrate 42, which is pressed  
38 against the intermediate transfer member by a heated backing

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1 roller 43. Heated backing roller 43 heats the paper and  
2 thereby heats the image in contact therewith by conduction  
3 from the paper, to a sufficient degree to ensure that  
4 complete or nearly complete final transfer of the image to  
5 the substrate, by heat and pressure, takes place.

6 While the invention has been described in a  
7 monochromatic version, where it gives improved transfer from  
8 the photoreceptor to the intermediate transfer member and  
9 from the intermediate transfer member to the final substrate,  
10 the invention is particularly useful in a multicolor system,  
11 wherein images of different colors are sequentially formed on  
12 photoreceptor surface 16, and transferred one by one in  
13 mutual alignment to image transfer member 40 prior to a  
14 single transfer of all of the images, which form a multicolor  
15 image, to final substrate 42.

16 Final substrate 42 is brought into transfer engagement  
17 with intermediate transfer member 40 only when all of the  
18 colors have been transferred to intermediate transfer member  
19 40, for final transfer of the multicolor image to substrate  
20 42.

21 As noted above, it is appreciated that during first  
22 transfer of subsequent images from photoreceptor surface 16  
23 to image transfer member 40, earlier transferred images  
24 return to the region of first transfer. Any back transfer of  
25 previously transferred images to photoreceptor surface 16  
26 will result in undesirable artifacts in the final printed  
27 image.

28 Generally if the intermediate transfer member is heated  
29 to a temperature which is useful for good final transfer,  
30 then there is a tendency for the image to back transfer to  
31 the photoreceptor.

32 The arrangement of Fig. 1, with proper choice of  
33 temperatures for intermediate transfer member 40 at first  
34 transfer, and for final substrate 42 and the image at second  
35 transfer in accordance with the present invention,  
36 substantially eliminates the problem of back transfer to  
37 photoreceptor surface 16, by keeping the image temperature,  
38 when the image on the intermediate transfer member returns to

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1 the photoreceptor, low enough so that it is not tacky enough  
2 to stick to the photoreceptor.

3 Fig. 2 shows a second embodiment of the invention in  
4 which all of the parts and operation are generally the same  
5 as those of the apparatus of Fig. 1, except that heated  
6 backing roller 43 is replaced by an unheated backing roller  
7 44, and final substrate 42 is preheated by a heating lamp 45.  
8 A combination of the embodiments of Figs. 1 and 2 is also  
9 useful, whereby paper 42 is pre-heated by lamp 45, and heated  
10 roller 43 is used.

11 A third embodiment of the apparatus of the invention is  
12 shown in Fig. 3A. In this case intermediate transfer member  
13 40 is heated to a first, moderate, temperature which is high  
14 enough to enhance first transfer, but not so high as to cause  
15 substantial back transfer of previously transferred images  
16 from intermediate transfer member 40 to photoreceptor surface  
17 16. The images are transferred to a second intermediate  
18 transfer member 47 which is heated by an internal heater 48  
19 to a higher temperature, sufficient to assure good final  
20 transfer to final substrate 42.

21 In a preferred embodiment of the invention, intermediate  
22 transfer member 40 is maintained at a first voltage  
23 (different from the voltage of the photoreceptor surface 16)  
24 to enhance transfer of the image thereto from photoreceptor  
25 surface 16, and second intermediate transfer member 47 is  
26 electrified to a second voltage, different from the first  
27 voltage, to enhance transfer of the image thereto from  
28 intermediate transfer member 40.

29 Transfer to second intermediate transfer member 47 can  
30 occur sequentially for each of the images, or preferably the  
31 images are collected on first intermediate transfer member 40  
32 and then the multicolor image is transferred as a whole to  
33 second intermediate transfer member 47 for final transfer to  
34 the final substrate 42.

35 Another embodiment of the apparatus of the invention is  
36 shown in Fig. 3B which is identical to the embodiment shown  
37 in Fig. 3A except that second intermediate transfer member 47  
38 has a smaller diameter and in consequence has less surface

1 area. In this embodiment, second intermediate transfer member  
2 47 cannot hold at any one moment in time the complete latent  
3 image which is being transferred from first intermediate  
4 transfer member 41. Thus, when the image is multicolor, all  
5 the multicolor images are first collected on the first  
6 intermediate transfer member and only thereafter is the  
7 composite image transferred to the second intermediate  
8 transfer member.

9 In this embodiment, the latent image is transferred from  
10 the second intermediate transfer member to final substrate 42  
11 virtually simultaneously as it is being transferred to second  
12 intermediate transfer member 47 from first intermediate  
13 transfer member 41. The inventors have discovered that this  
14 configuration results in an enhancement of the quality of the  
15 image produced on the final substrate when compared with a  
16 configuration in which the second intermediate transfer  
17 member is full-sized. In the latter case, the final substrate  
18 tends to adhere to the surface of the second intermediate  
19 transfer member as the image is being transferred, thereby  
20 causing a certain blurring of the image on the final  
21 substrate. When the second intermediate transfer member has a  
22 relatively small diameter, preferably less than 40 mm and  
23 more preferably less than 30 mm, the separation of the final  
24 substrate from the transfer member is improved, there is less  
25 tendency to adhesion, and the quality of the image on the  
26 final substrate is thereby enhanced. In particular when the  
27 first intermediate transfer member has a diameter of 70 mm or  
28 more, as required to hold an A4 sized image, or a 100 mm  
29 diameter or more, as required to hold an A3 sized image,  
30 optimal results will be obtained when intermediate transfer  
31 member 47 has a diameter of less than about 40 mm or less,  
32 preferably about 30 mm or less.

33 A duplex embodiment of the invention, for  
34 printing two sides of a substrate at the same time is shown  
35 in Fig. 4. The separate color images which make up the multi-  
36 colored image to be printed on a first side of substrate 42  
37 are first transferred sequentially to intermediate transfer  
38 member 40 and then are transferred, preferably as a group, to

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1 second intermediate transfer memb r 47. Second image transfer  
2 memb r 47 is preferably heated to a higher temperatur than  
3 intermediate transfer member 40. The images to be printed on  
4 the other side of the page are subsequently transferred  
5 sequentially to intermediate transfer member 40, which is  
6 meanwhile kept out of transfer engagement with second  
7 intermediate transfer member 47.

8 Final substrate 42 is then passed between intermediate  
9 transfer member 40 and second intermediate transfer member  
10 47, while pressing the two intermediate transfer members  
11 together to effect transfer of the images to both sides of  
12 the paper by heat and pressure. It is understood that  
13 preferably second intermediate transfer member 47 heats  
14 substrate 42 and the image to a suitable temperature to  
15 assure good transfer of the image on intermediate transfer  
16 member 40 to substrate 42. Alternatively or additionally, the  
17 paper may be heated before transfer as described above in  
18 connection with Fig. 2.

19 In some preferred embodiments of the invention  
20 intermediate transfer member 40 acts to heat the image to a  
21 first temperature during first transfer from photoreceptor 16  
22 to intermediate transfer member 40, and to heat the image to  
23 a second higher temperature before second and final transfer  
24 from intermediate transfer member 40 to final substrate 42.

25 Exemplary embodiments include the apparatus shown in  
26 Fig. 5. This apparatus is generally the same as the apparatus  
27 of Fig. 1, except that a cooling station 60 is operatively  
28 associated with intermediate transfer member 40 just before  
29 it returns to make contact with photoreceptor surface 16.  
30 Intermediate transfer member 40 is cooled at cooling station  
31 60 to locally reduce the temperature of intermediate transfer  
32 member 40 before and during contact with the image on the  
33 photoreceptor. This local cooling allows the liquid toner  
34 image to be hotter at the point of final transfer from  
35 intermediate transfer member 40 to final substrate 42 than it  
36 is at first transfer from photoreceptor surface 16 to  
37 intermediate transfer member 40.

38 Cooling station 60 may comprise, for example, apparatus

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1 for providing a stream of cool air to the surface of the  
2 photoreceptor or a cooled roller in contact with the  
3 photoreceptor surface. Either or both cooling systems cool  
4 intermediate transfer member 40 to a temperature, higher than  
5 room temperature, but lower than the final transfer  
6 temperature.

7 In a multicolor system, if a roller cooler is used it is  
8 coated with a non-stick coating to avoid transfer of the  
9 image from intermediate transfer member 40 to the roller of  
10 cooling station 60.

11 Another exemplary embodiment of this type is illustrated  
12 in Fig. 6, which is essentially the same as Fig. 8 of WO  
13 90/04216 previously referenced. Here an intermediate transfer  
14 member 140 is of low heat capacity, and is heated only after  
15 first transfer is completed. As shown in Fig. 7, which is the  
16 same as Fig. 9 of the above referenced application, the  
17 temperature at the first transfer is above room temperature  
18 in order to improve first transfer, and the temperature at  
19 second transfer is even higher to assure complete or nearly  
20 complete second transfer. For a multi-color system the  
21 temperatures and heat capacities are selected so that the  
22 first transfer takes place at a temperature low enough to  
23 avoid back transfer.

24 In the above embodiments, intermediate transfer members  
25 40 and 47 have been described as having heaters placed  
26 internal to the core to heat each of them to its required  
27 temperature. Other methods of heating intermediate transfer  
28 members known in the art can also be used in the practice of  
29 the invention.

30 **Examples**

31 Colored liquid developer is prepared in the following  
32 manner:

33 **Preparation of Black Liquid Developer**

34 10 parts by weight of Elvax 5720 (E. I. Du Pont) and 5  
35 parts by weight of Isopar L are mixed at low speed in a  
36 jacketed double planetary mixer connected to an oil heating  
37 unit for one hour, the heating unit being set at 130°C.

38 A mixture of 2.5 parts by weight of Mogul L carbon black

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1 (Cabot) and 5 parts by weight of Isopar L are then added to  
2 the mix in the double planetary mixer and the resultant  
3 mixture is further mixed for one hour at high speed. 20 parts  
4 by weight of Isopar L preheated to 110°C are added to the  
5 mixer and mixing is continued at high speed for one hour. The  
6 heating unit is then disconnected and mixing is continued  
7 until the temperature of the mixture drops to 40°C.

8 The resulting mixture is transferred to an S-1 attritor  
9 device equipped with 3/16 inch carbon steel media, diluted  
10 with Isopar L to a 16% solids ratio and ground without  
11 cooling until the temperature rises to about 60°C. Cooling,  
12 which reduces the temperature to about 30°C is then commenced  
13 and grinding is continued for a total of 24 hours. The  
14 mixture is removed from the device and diluted with Isopar L  
15 to 1.5% by weight solids concentration. The particles in the  
16 resultant toner concentrate have an average diameter of 2.5  
17 microns.

18 Charge director as known in the art, is added to give  
19 the final liquid developer. In a preferred embodiment of the  
20 invention the charge director of Example 1 of PCT publicatione dis

22 reference, is added to give the final liquid developer.

#### 23 Preparation of Colored Developer

24 10 parts by weight of Elvax 5720 (E. I. Du Pont) and 5  
25 parts by weight of Isopar L are mixed at low speed in a  
26 jacketed double planetary mixer connected to an oil heating  
27 unit for one hour, the heating unit being set at 130°C.

28 Pre-heated Isopar L is then added to reduce the solids  
29 concentration to preferably 35% and mixing is continued at  
30 high speed for one hour. The heating unit is then  
31 disconnected and mixing is continued until the temperature of  
32 the mixture drops to 40°C.

33 The mixture is then transferred to an S-1 attritor  
34 device equipped with 3/16 inch carbon steel media and pigment  
35 is added to the material in the attritor. The mixture is  
36 diluted with Isopar L to about a 12-16% solids ratio,  
37 depending on the viscosity of the material and is ground  
38 without cooling until the temperature rises to about 60°C.

- 17 -

1 Cooling, which reduces the temperature to about 30°C, is then  
2 commenced and grinding is continued for a total of 24 hours.  
3 The mixture is removed from the device and diluted with  
4 Isopar L to 1.5% by weight solids concentration. The  
5 particles in the resultant toner concentrate had an average  
6 diameter of 2.5 microns.

7 Charge director as known in the art, is added to give  
8 the final liquid developer. In a preferred embodiment of the  
9 invention the charge director of Example 1 the above  
10 referenced PCT publication WO 90/14617 is added to give the  
11 final liquid developer.

12 Appropriate colored pigments known in the art of liquid  
13 developer manufacture, for example the list given in U. S.  
14 Patent 4,794,561 can be used. Other suitable pigments are  
15 Sico Fast Yellow D1350 (BASF), Lithol Rubin D4576 (BASF),  
16 Lyonol Blue FG7351 (TOYO) and Lyonol Yellow 7G1310 (TOYO). in  
17 amounts and combinations depending on the color and intensity  
18 required. Optionally, Aluminum Stearate can be added in small  
19 amounts. For pigments which are discolored by steel, other  
20 grinding media such as zirconia may be used.

21 These developers are used to form the individual color  
22 liquid toner images on photoreceptor surface 16 which  
23 comprise a relatively high concentration of toner particles  
24 in carrier liquid.

25 Photoreceptor surface 16 is preferably formed of  
26 selenium. Intermediate transfer member 40 is preferably  
27 formed of a cylindrical aluminum core coated with a 1 mm  
28 thick layer of very soft polyurethane having a hardness of  
29 20-25 Shore A. This layer is covered by an offset printing  
30 blanket, preferably a KYNIO AIRTACK offset blanket, which is  
31 much harder than the polyurethane. A thin conducting layer of  
32 conducting acrylic covers this layer and is covered in turn  
33 by a 0.1 mm layer of polyurethane of shore A Hardness 20.  
34 This layer is overcoated by a thin layer of Syl-Off type 291  
35 or 294 silicone release coating.

36 Liquid developer prepared in accordance with the method  
37 described above is used in the equipment of Fig. 1.  
38 Preferably the temperature of the intermediate transfer layer

- 18 -

1 should be less than about 50° C. For temperatures greater than about 50 degrees, there is a tendency for the previously transferred colors to back transfer to photoreceptor surface 16. Heating intermediate transfer member 40 improves image transfer to intermediate transfer member 40. Intermediate transfer member 40 is preferably heated to a temperature somewhat below that at which back transfer begins to occur.

8 It is believed that the improvement in first transfer when the intermediate transfer member is heated may be a consequence of partial solvation of carrier liquid by the pigmented toner particles in the image.

12 One characteristic of the liquid developers preferred in the practice of this invention is that the pigmented toner particles contained therein solvate the carrier liquid at elevated temperatures. It is believed that there is a partial solvation of the carrier liquid in the toner particles during first transfer to heated intermediate transfer member 40 which may cause the particles to partially coalesce and form a film during first transfer. Coalesced toner is believed to transfer better than uncoalesced toner particles.

21 Furthermore, when the toner material solvates some of the carrier liquid, the toner particles separate from the unsolvated carrier liquid. It is believed that this separated carrier liquid forms a film between the toner image and the photoreceptor which reduces the adhesion of the image to the photoreceptor, aiding complete transfer of the image to the intermediate transfer member.

28 It is to be understood that the heating of the image before and/or during final transfer insures the complete or nearly complete transfer of the image from the intermediate transfer member to the final substrate. Where this image heating comes solely by conduction from the paper, it has been found experimentally that the paper should be at a temperature of at least about 70° C. Higher temperatures such as 80 or 90° can also be used, but substantially lower temperatures do not tackify the image enough to assure complete transfer from intermediate transfer member 40 to paper 42.

1 The precise temperatures used for particular  
2 configurations and combinations are a function of the  
3 material properties of the toner particles and the carrier  
4 liquid as well as of the quality of the release layer on the  
5 intermediate transfer member. Back transfer occurs due to the  
6 tackiness of the image, but is also influenced by the  
7 relative adhesion of the image to the release layer on the  
8 intermediate transfer member and to the photoreceptor. It  
9 would be possible to increase the temperature of the  
10 intermediate transfer member if the release properties of the  
11 surface of the intermediate transfer member were poorer. This  
12 however would also result in poorer transfer to the final  
13 substrate.

14 In particular representative, operating examples the  
15 following temperatures are used. In a first example, which is  
16 used for the transfer of single color images, the  
17 intermediate transfer member is heated to a surface  
18 temperature of 100°C and the paper is not heated.  
19 Calculations show that the image is at a temperature of 52°C  
20 to 63°C during first transfer. During the interval between  
21 first and second transfer the image temperature rises to the  
22 intermediate transfer member's temperature of 100° C, and the  
23 image is cooled during second, final transfer to paper to a  
24 temperature of 73°C to 78°C.

25 In a second, representative, operating example for  
26 sequential transfer of multiple images to the intermediate  
27 transfer member, the intermediate transfer member is heated  
28 to 50° C and backing roller 43 is heated to 120° C. The image  
29 temperature on first transfer is approximately 43° C and on  
30 second transfer it is 75°C to 78°C.

31 The temperatures shown in figure 7 are also  
32 representative of values suitable for single image transfer.  
33 For multi-image transfer to intermediate transfer member 140,  
34 the first transfer temperature must be low enough to assure  
35 that no back transfer takes place.

36 It will be understood that certain features and sub-  
37 combinations of the invention are useful, and may be employed  
38 without other features and sub-combinations. It is noted that

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1 various changes may be made in details within the scope of  
2 the claims without departing from the spirit of the  
3 invention. It is therefore to be understood that the  
4 invention is not to be limited to the specific details shown  
5 and described.

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CLAIMS

2 1. Imaging apparatus for printing an image on a substrate  
3 from a latent image formed on a latent image bearing surface  
4 comprising:

5 developing means for developing said latent image with  
6 toner to form a developed toner image of a given size;

7 a first intermediate transfer member having a surface  
8 area large enough to accommodate said developed toner image;

9 first transfer means for transferring said developed  
10 toner image from said latent image bearing surface to said  
11 first intermediate transfer member;

12 a second intermediate transfer member having a surface  
13 area smaller than the surface area of said first intermediate  
14 transfer member; and

15 second transfer means for transferring of said developed  
16 image from said first intermediate transfer member to said  
17 second intermediate transfer member and from said second  
18 intermediate transfer member to said substrate.

19

20 2. Imaging apparatus according to claim 1 wherein the second  
21 intermediate transfer member is not large enough to  
22 accomodate said developed image.

23

24 3. Imaging apparatus according any of the preceding claims  
25 and including:

26 intermediate transfer member heating means for heating  
27 said first intermediate transfer member to a first  
28 temperature and for heating said second intermediate transfer  
29 member to a second temperature higher than said first  
30 temperature.

31

32 4. Imaging apparatus according any of the preceding claims  
33 wherein said second transfer means includes second heating  
34 means for heating said substrate.

35

36 5. Imaging apparatus according to claim 4 wherein said  
37 second heating means comprises a heating backing roller  
38 operative to apply heat and pressure to said image during

- 22 -

1 said image transfer.

2

3 6. Imaging apparatus according to any of the preceding  
4 claims and also including first voltage means for maintaining  
5 said first intermediate transfer member at a first voltage.

6

7 7. Imaging apparatus according to claim 6 wherein at least a  
8 portion of said latent image bearing surface is at a second  
9 voltage and said first voltage is different from said second  
10 voltage.

11

12 8. Imaging apparatus according to claim 6 or claim 7 and  
13 also including second voltage means for maintaining said  
14 second intermediate transfer member at a third voltage.

15

16 9. Imaging apparatus according to any of the preceding  
17 claims wherein said toner is a liquid toner comprising  
18 carrier liquid and toner particles.

19

20 10. Apparatus according to any of the preceding claims  
21 wherein said first intermediate transfer member is  
22 cylindrical.

23

24 11. Imaging apparatus according to claim 10 wherein said  
25 second intermediate transfer member has a diameter of less  
26 than about 40 mm.

27

28 12. Imaging apparatus according to claim 10 wherein said  
29 second intermediate transfer member has a diameter of less  
30 than about 30 mm.

31

32 13. Imaging apparatus according to any of the preceding  
33 claims wherein transfer of the developed image from said  
34 second intermediate transfer member to said substrate  
35 commences before transfer of said developed image from said  
36 first intermediate transfer member to said second transfer  
37 member is complete.

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1 14. Imaging apparatus according to any of the preceding  
2 claims wherein said apparatus includes means for producing a  
3 plurality of developed images on said image bearing surface  
4 and for transferring said plurality of developed images to  
5 said first transfer member in mutual alignment thereon.

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FIG. 1

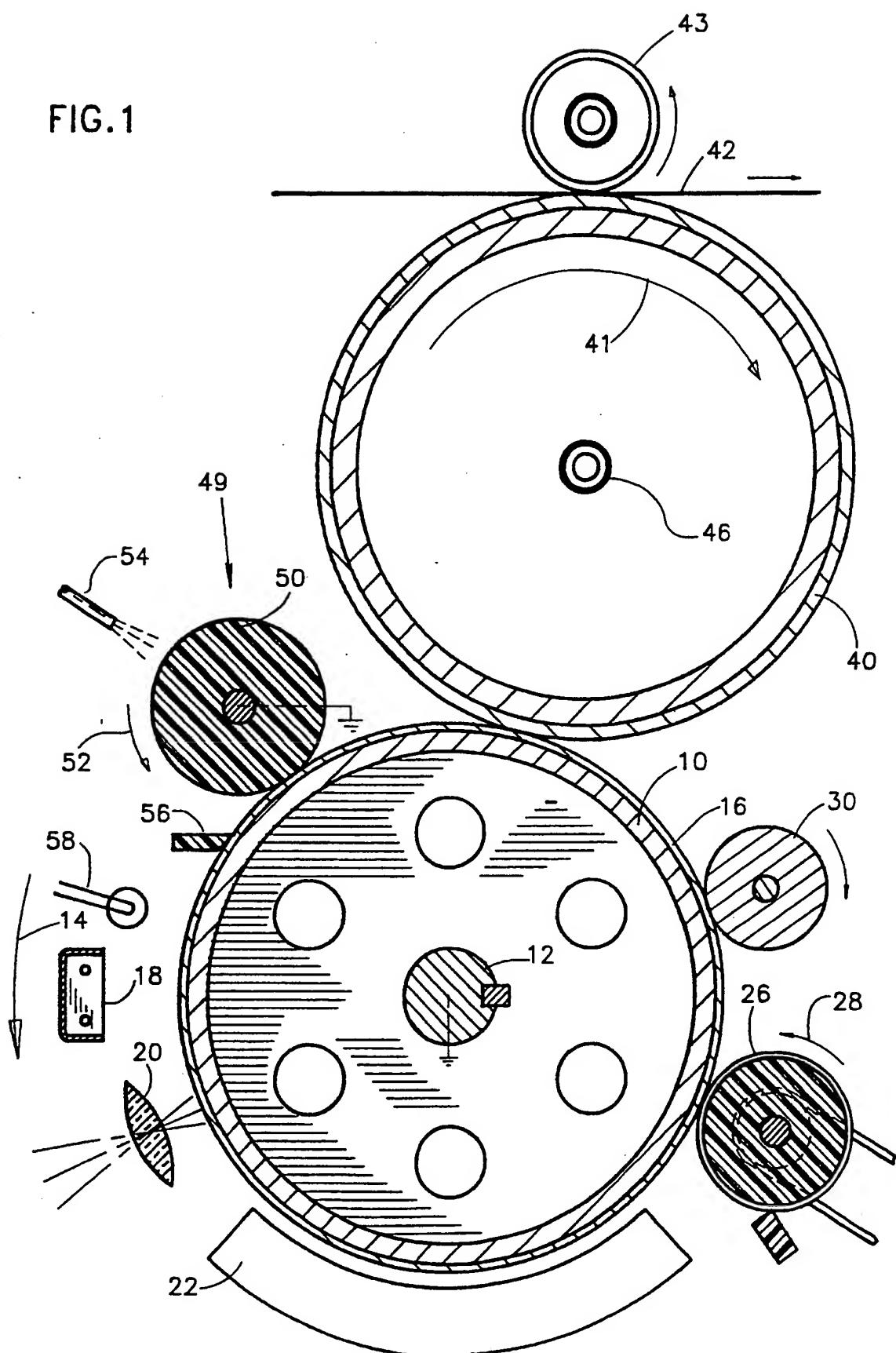
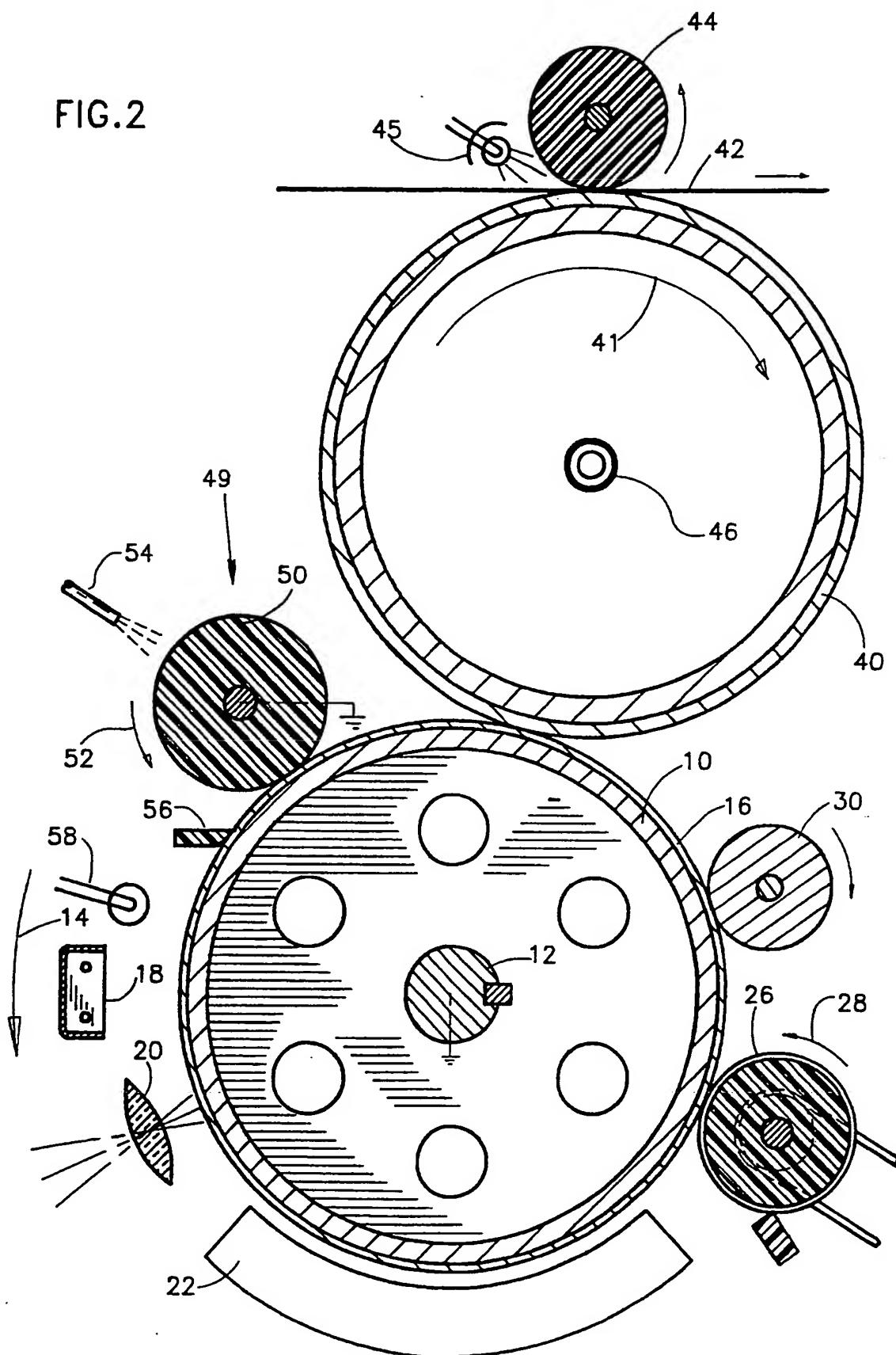


FIG.2



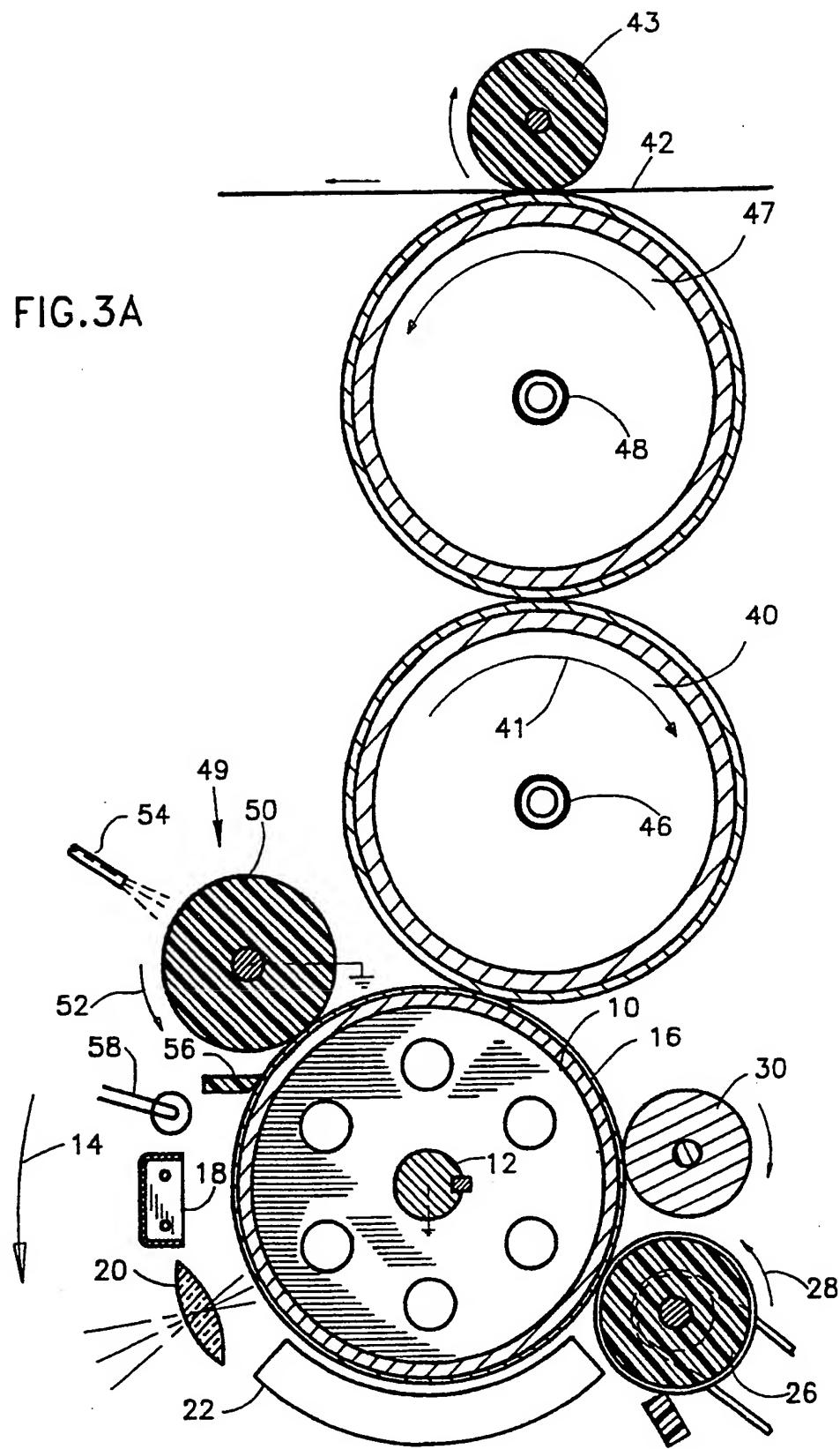


FIG.3B

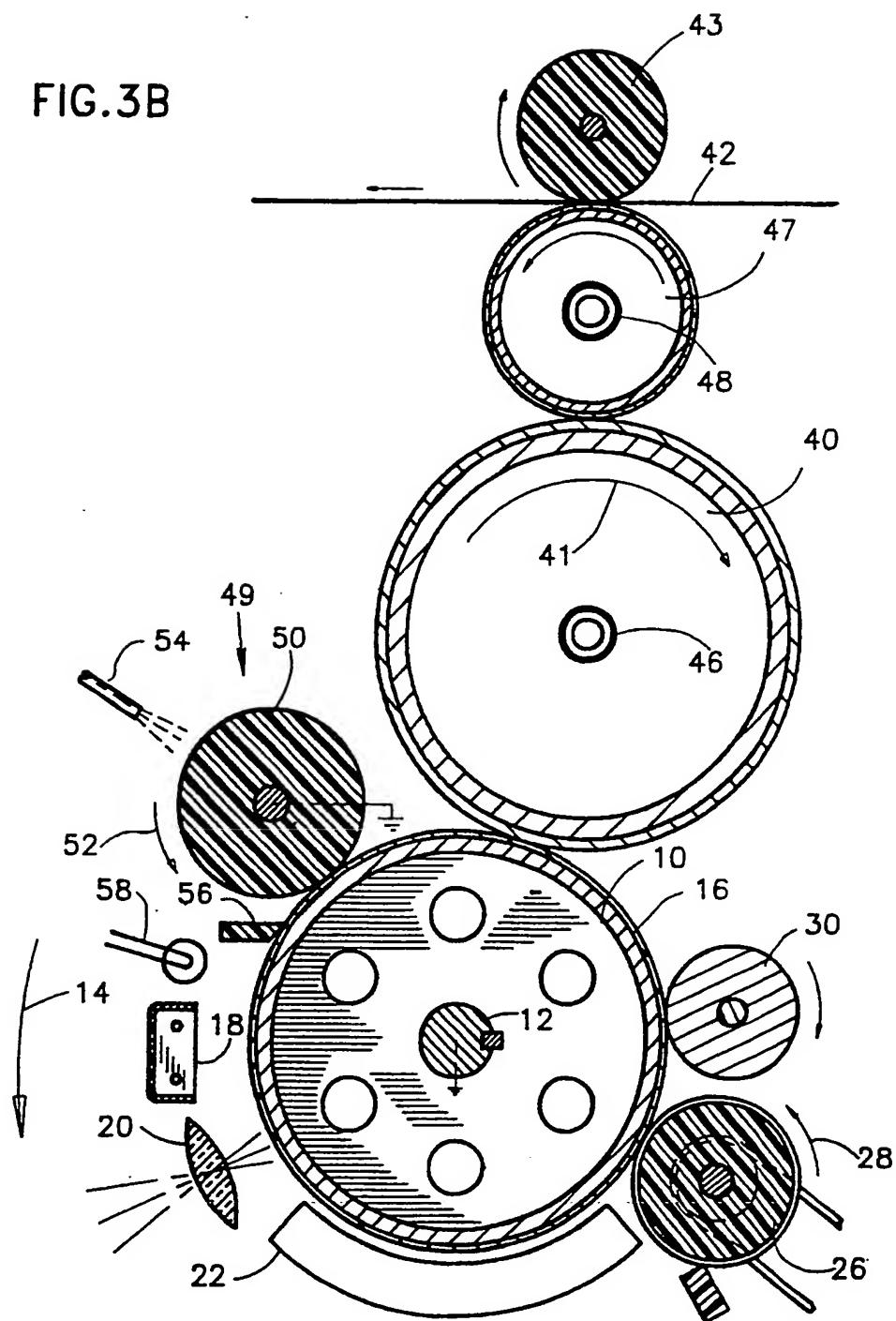


FIG.4

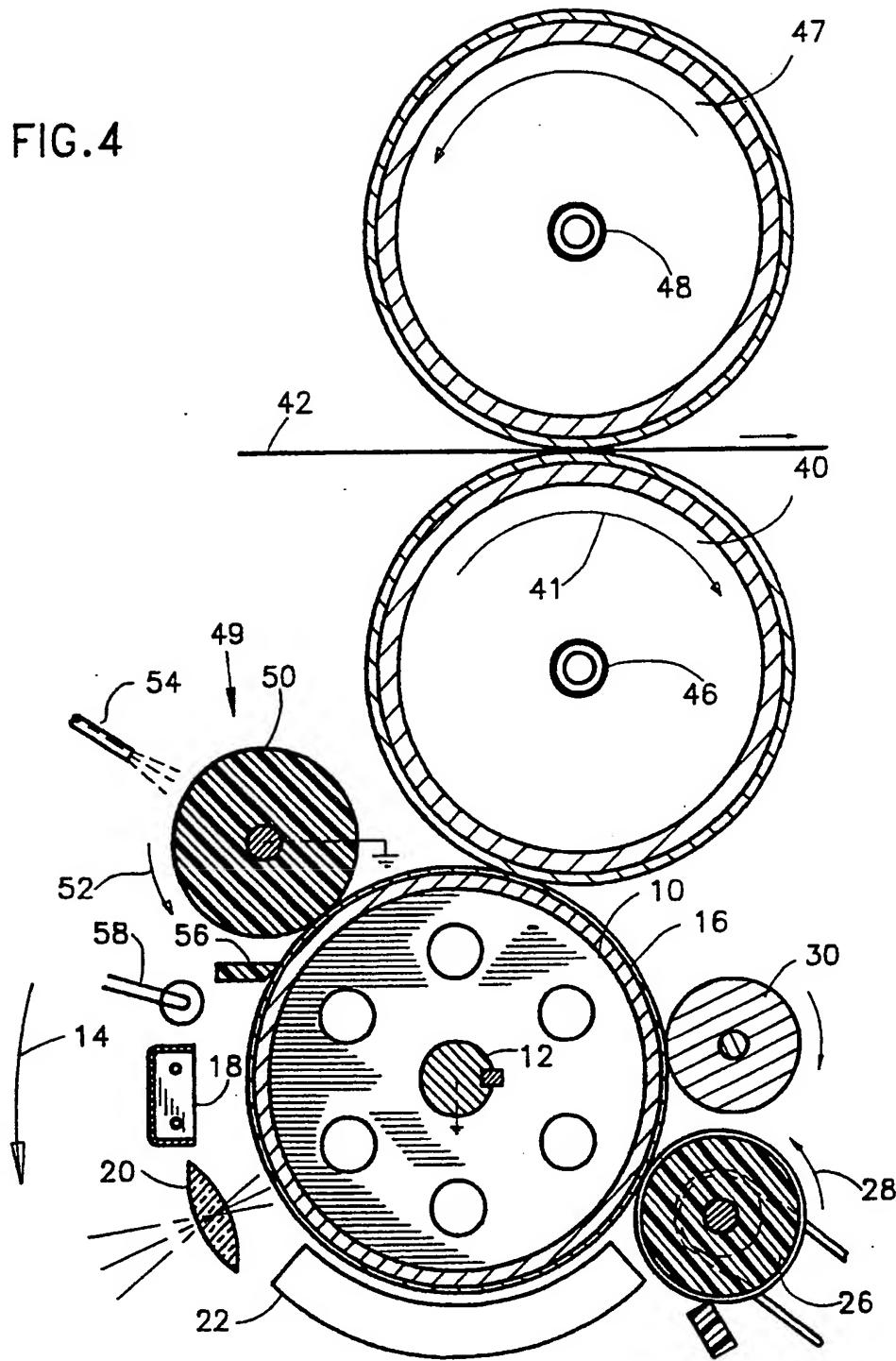
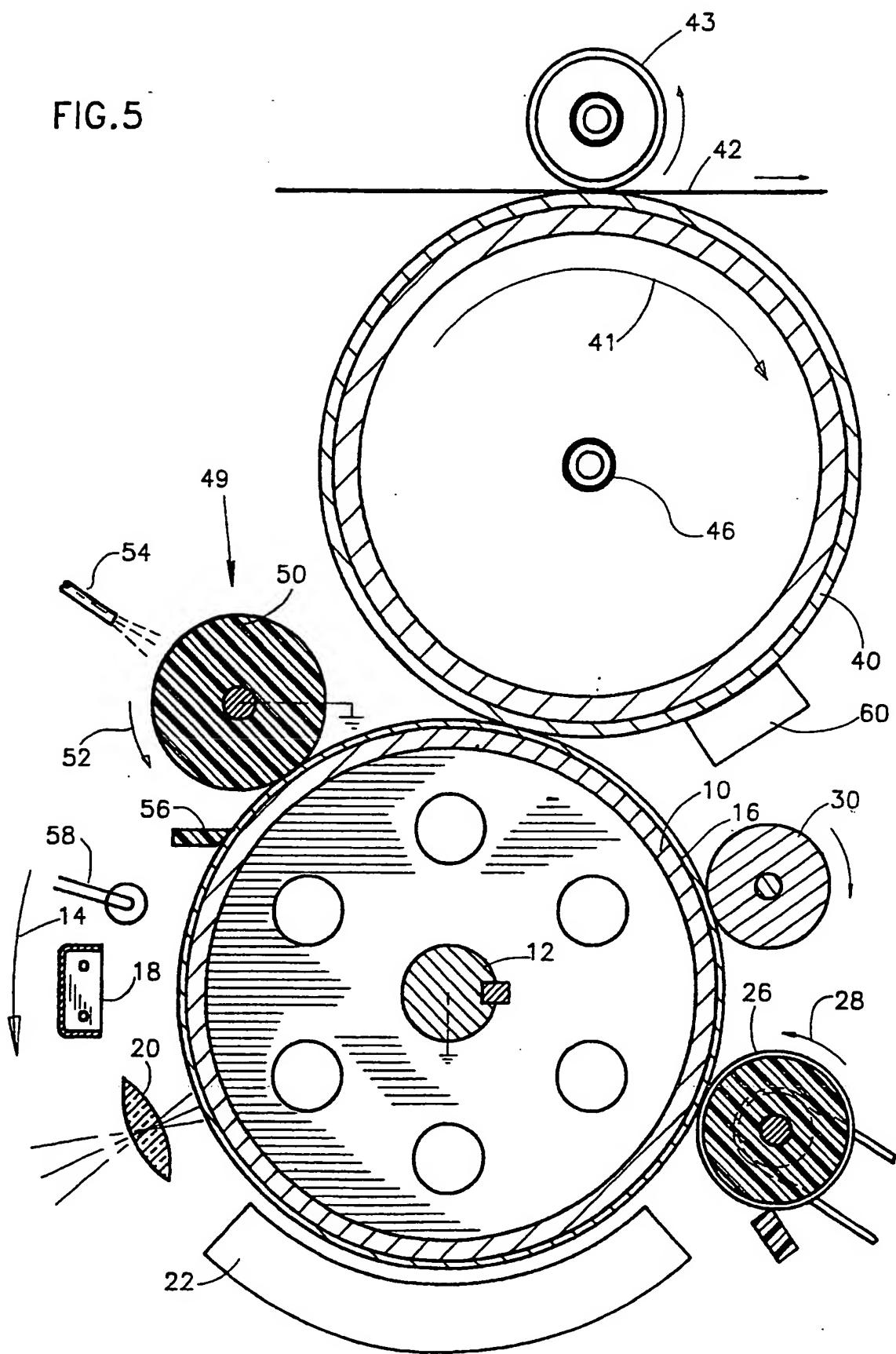
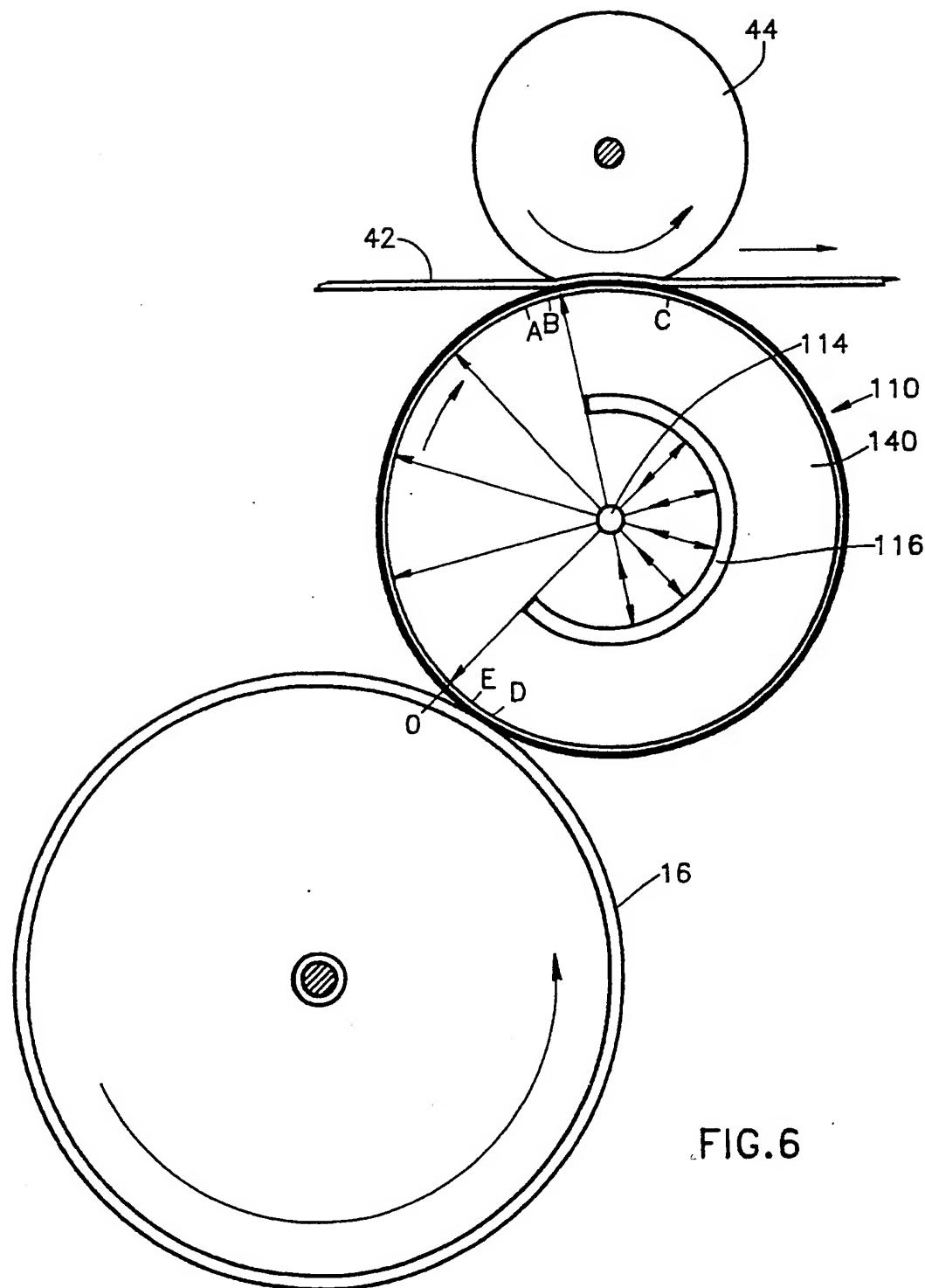
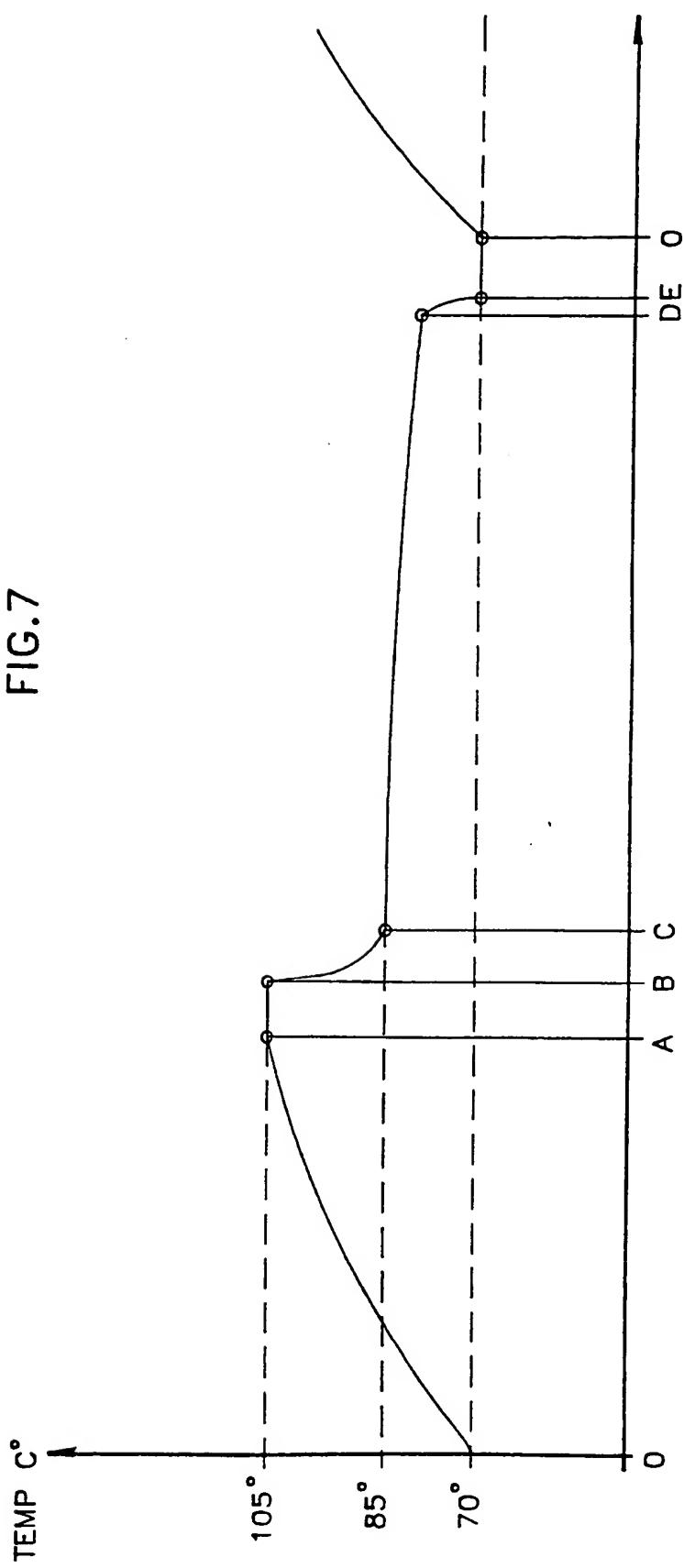


FIG.5







## INTERNATIONAL SEARCH REPORT

International Application No

PCT/NL 91/00050

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)<sup>6</sup>

According to International Patent Classification (IPC) or to both National Classification and IPC.

Int.Cl. 5 G03G15/16; G03G15/01

## II. FIELDS SEARCHED

Minimum Documentation Searched<sup>7</sup>

Classification System	Classification Symbols
Int.Cl. 5	G03G

Documentation Searched other than Minimum Documentation  
to the Extent that such Documents are Included in the Fields Searched<sup>8</sup>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup>

Category <sup>10</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
X	PATENT ABSTRACTS OF JAPAN vol. 12, no. 243 (P-728)(3090) 9 July 1988 & JP,A,63 034 572 ( FUJI XEROX CO LTD ) 15 February 1988 see abstract ---	1, 4
X	PATENT ABSTRACTS OF JAPAN vol. 11, no. 358 (P-639)(2805) 21 November 1987 & JP,A,62 134 674 ( CANON INC ) 17 June 1987 see abstract ---	1, 4, 5, 10
A	PATENT ABSTRACTS OF JAPAN vol. 6, no. 59 (P-110)(937) 16 April 1982 & JP,A,57 002 048 ( RICOH K.K. ) 7 January 1982 see abstract ---	1, 4, 10 -/-

\* Special categories of cited documents :<sup>10</sup>

- "A" document defining the general state of the art which is not considered to be of particular relevance
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&amp;" document member of the same patent family

## IV. CERTIFICATION

Date of the Actual Completion of the International Search

1 27 NOVEMBER 1991

Date of Mailing of this International Search Report

18. 12. 91

International Searching Authority

EUROPEAN PATENT OFFICE

Signature of Authorized Officer

CIGOJ P. M.

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	WO,A,9 004 216 (SPECTRUM SCIENCES B.V.) 19 April 1990 cited in the application see claims 22-25; figure 1	1,3,9, 10,14

ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO. NL 9100050  
SA 46422

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.  
The members are as contained in the European Patent Office EDP file on  
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A-9004216	19-04-90	EP-A- 0437546	24-07-91